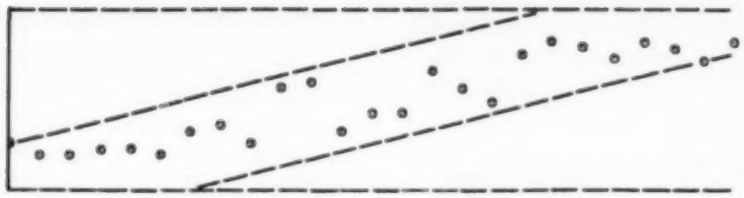
INDUSTRIAL QUALITY CONTROL



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THE SOCIETY OF QUALITY CONTROL ENGINEERS

NATIONAL ORGANIZATION

The formation of a national quality control society continues to be a matter of first rate importance to quality control operators all over the country. Recently a concrete move toward such organization has been made by the National Research Council. The subscribers to INDUSTRIAL QUALITY CONTROL will be interested in three things: (1) what is the National Research Council? (2) what is its proposal? (3) what is the relation of the subscribers to the proposal?

Your editor does not possess an organizational blueprint of the N.R.C. or a statement of its purposes and functioning method. However, it appears from the outside that the N.R.C. has received a request from leaders in the quality control field that the Council act as a clearinghouse for information and a focal point for initial action in the organization of a national quality control society. To carry out this objective the N.R.C. appointed a Subcommittee on Quality Control of its standing Committee on Applied Mathematical Statistics. The Subcommittee has submitted a proposal for the selection of an organizing committee which will proceed with the formulation of plans for launching a National Quality Control Society.

The following is a summary of the Subcommittee proposal. Any national organization should have the fullest support of all persons interested in industrial quality control. The town meeting plan of organization is not feasible because of the distances involved and because no one knows all of the quality control operators who should attend such a meeting. On the other hand there are 28 local quality control groups operating in various sections of the country. With one exception these groups have sprung from the eight-day intensive courses sponsored by the Office of Production Research and Development of the War Production Board. These local groups carry on their membership lists some 1800 persons who have completed the eight-day course, plus a major fraction of an additional 2500 persons who have studied quality control in part time courses offered by universities and technical schools.

The Organizing Committee for a National quality control society is to be composed of one representative from each of the 28 local groups and five representatives at large. Each local group is to appoint its representative and to submit the names of five persons for the representatives at large. The Subcommittee of N.R.C. will tabulate the nominations for representative at large and submit the list to each of the 28 local representatives with a request that he vote for five of the nominees. This vote will be tabulated by the Subcommittee and the names of the 10 nominees receiving the highest number of votes will again be submitted to the 28 local representatives with a request that they vote for 5 of the 10 nominees. When these votes have been tabulated by the Subcommittee the 5 nominees receiving the greatest number of votes will be declared elected as the 5 representatives at large on the Organizing Committee. The nominee receiving the largest number of votes will become chairman of the Organizing Committee.

At this point the National Research Council will have completed its function and will withdraw from the proceedings. The Chairman of the Organizing Committee will then convene the complete Committee for the purpose of setting up a detailed plan of organization for a National Society.

The Subcommittee has evolved a plan for national organization. Some of its features may appear to be clumsy but it has the merit of attempting to produce a representative Committee. The weakness of the plan would appear to be its failure to give sufficient recognition to well established quality control operators.

Not more than 30 percent of the subscribers to INDUSTRIAL QUALITY CONTROL have any connection with the twenty-eight local groups who will be represented in the proposed organizing committee. Hence for most of you this will be the first knowledge of the organizing plan. Yet it will be apparent that you and members of your organizations are the ones who will provide a major segment of support of any successful national organization. This circumstance is given nominal recognition in the report of the Subcommittee of the N.R.C., but the Subcommittee has overlooked an obvious opportunity to provide direct representation to you on the Organizing Committee. The five members at large of the Organizing Committee should have been chosen from the subscription list of INDUSTRIAL QUALITY CONTROL. There exists nowhere else even a semblance of a list of the concerns that are using statistical quality control.

It is too late to make this change in the Subcommittee plan. But it is quite feasible to correct the omission. The twenty-eight representatives of the existing groups should cast their ballots for five men who are now in charge of quality control installations. Only by following this plan can the Organizing Committee give direct representation to the established industrial segment of the potential membership of a future national society.

The men who meet this specification are well known to the 28 local representatives because many of them have appeared from time to time as members of the faculty of the eight-day courses.

ANALYSIS OF DOUBLE SAMPLING PLAN

By

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The elimination of all defective items in a group offered for acceptance may be accomplished only by an examination of each and every item for conformance with specification requirements. This procedure may result, however, in the acceptance of some defective items and in the rejection of some passable items unless the utmost care is taken by the inspection personnel. Even then there is a very great possibility that the inspection procedure will not result in the elimination of all defective items.

There are a number of reasons for this, the most important being fatigue caused by the inability of the average inspection operator to concentrate for long periods of time on a repetitive operation. The same might be said of any repetitive process and is undoubtedly one of the contributing causes for defects on many production lines. The fact that defects are produced in the normal course of events gives rise to the necessity for some means of detecting them once produced.

If the resulting effect can be tolerated it may be sound economically to allow a predetermined percentage of defectives to flow along with the effectives until some point is reached in the assembly where their presence becomes noticeable in the fabrication of the product. As mentioned above, however, it is sometimes necessary to eliminate as many as possible of the non-conforming items. This requires careful inspection of all units in the group. In other instances, it may be possible to tolerate a certain percentage of defectives provided a means can be found for evaluating and controlling the flow of such defective parts.

A ready means of determining the above is to select a random sample and measure it for the characteristic or characteristics involved. If the sample is random, is of the proper size and is selected from a homogeneous universe it will represent quite accurately the composition of the lot from which it was selected. Many sampling schemes are proposed and used. Some are designed to represent the lot quite accurately. Others are biased depending on lot or sample size and upon the fraction defective in the submitted product.

A very great amount of study has been given to the subject of sampling and to the design of sampling plans. These plans may be divided into several groups such as single sampling, double sampling, multiple sampling, progressive sampling, etc. Of the plans mentioned, those which have found the greatest favor and which are relatively simple in operation are of the single and double sampling variety. Perhaps the reason for this is the large number of tables which have been prepared and which have received quite universal acceptance.

One of these double sampling plans which has been specified by the Services for the acceptance of certain material is described as follows:

If the lot size is between 3200 and 7999, take a first sample of 150 units and allow three defects. If more than three (3) defects are found in the first sample take an additional sample of 300 pieces and accept if the number of defects in both samples combined does not exceed nine (9).

The primary purpose of this discussion is to analyze the above plan, to show how it operates by constructing the operating and average outgoing quality characteristics and to offer such additional comments as may be helpful to those having occasion to analyze similar plans.

As mentioned above, a random sample selected from a homogeneous universe is representative of the contents of that universe. The problem, therefore, is to determine just what relation exists between the sample and the universe from which it was selected and to translate that information into useful and usable data. This is where the laws of probability have been found most useful and will be utilized in preparing an analysis of the above mentioned double sampling plan.

When the fraction defective (p) is less than 0.10, the probability of finding (m) defects in a random sample of (n) pieces drawn from an infinite universe is given by

the (m + 1) term of the Poisson exponential distribution

$$P_{m,pn} = e^{-pn}\frac{(pn)^m}{m!} \qquad (1)$$

The probability of meeting the acceptance numbers (c=3 for first sample and $c_1+c_2=9$ for combined samples) specified by the plan from a product of fraction defective (p) is designated the probability of acceptance (P_a). For single sampling:

$$P_a = \sum_{m=0}^{m=c} P_{m,pn} \qquad (2)$$

For the first sample (n_1) of 150 pieces, the probability of acceptance (P_{a_1}) is equal to the sum of the probabilities of finding exactly 0, 1, 2, and 3 defects in the sample. These values when substituted in Equations (1) and (2) above result in a total probability of acceptance for each value of (p). For example assume (p) equals 0.02 and (m) equals 0, 1, 2, and 3 respectively, from

$$(2)\quad P_{a_1} = \sum_{m=0}^{m=3} P_{m,3} \quad P_{0,3}+P_{1,3}+P_{2,3}+P_{3,3} \qquad (3)$$

When substituted in Equation (1)

$$P_{0,3} = \frac{e^{-3}(3)^0}{1} = .049787$$

$$P_{1,3} = \frac{e^{-3}(3)^1}{1} = .149361$$

$$P_{2,3} = \frac{e^{-3}(3)^2}{2\cdot 1} = .224042$$

$$P_{3,3} = \frac{e^{-3}(3)^3}{3\cdot 2\cdot 1} = .224042$$

and $$P_{a_1} = \sum = .647232$$

Where P_{a_1} = Probability of acceptance for first sample only

m = 0, 1, 2, 3 defectives respectively

P_m = Probability of finding exactly 0, 1, 2 or 3 defectives respectively

and pn = Fraction defective in submitted product times sample size = 0.02 x 150 = 3.

Additional values of P_{a_1} may be calculated similarly for any value of fraction defective (p) by substituting the proper values in Equation (1) above. In making these substitutions it should be kept in mind that factorial zero (0!) = 1. Sufficient points should be determined in order that the final result will appear as the smooth line (1) of Figure I.

The use of the formula results in laborious calculations that can be avoided by the use of tables [1] or charts [2]. Reference to Table I for individual terms of the Poisson distribution gives the individual probabilities of finding exactly 0, 1, 2, 3 ..... m defectives. To use the table, enter at the value of "a" equal to pn. For the example used here, a = 3. Opposite x = 0, read .049787; opposite x = 1, read .149361; opposite x = 2, read .224042; and opposite x = 3, read .224042. These are the probabilities of finding exactly 0, 1, 2, or 3 defectives respectively in the sample and the values correspond to those calculated above. The sum of the values is P_{a_1} and is .647232. Summation of the individual terms may be avoided by reference to Table II for cumulated terms. In this usage, the tables are entered at "a" corresponding to pn and "x" corresponding to the (m + 1) term. For the example used here, a = 3 and (m + 1) = 4. Opposite x = 4 read .352768. This value, when subtracted from 1.000000, gives .647232 as above.

In most work, the accuracy of six place tables is not required. The use of the cumulative probability curves is quick and of sufficient accuracy. To use the curves, enter at the bottom corresponding to the desired value of pn. Follow the line upward to the intersection with the curve corresponding to the correct value of "c", and opposite the intersection read the probability of acceptance on the vertical scale. For the example used here, pn = 3 and c = 3. Opposite the intersection of the lines, read .65 which agrees with that previously found.

Having determined the Probability of Acceptance vs Fraction Defective in Submitted Product relationship for the first sample size

1. Poisson's Exponential Binomial Limit, E. C. Molina, D. Van Nostrand Company, Inc., New York, New York.
2. Cumulative Probability Curves - Poisson Exponential Figure 6, Sampling Inspection Tables, H.F. Dodge and H. G. Romig, John Wiley and Sons, Inc., New York, N York.

of 150 as shown by (1) of Curve I, it now becomes necessary to consider what happens in case the number of defectives found in the first sample exceeds 3. When this occurs it is necessary to select an additional random sample of 300 pieces and continue with the inspection.

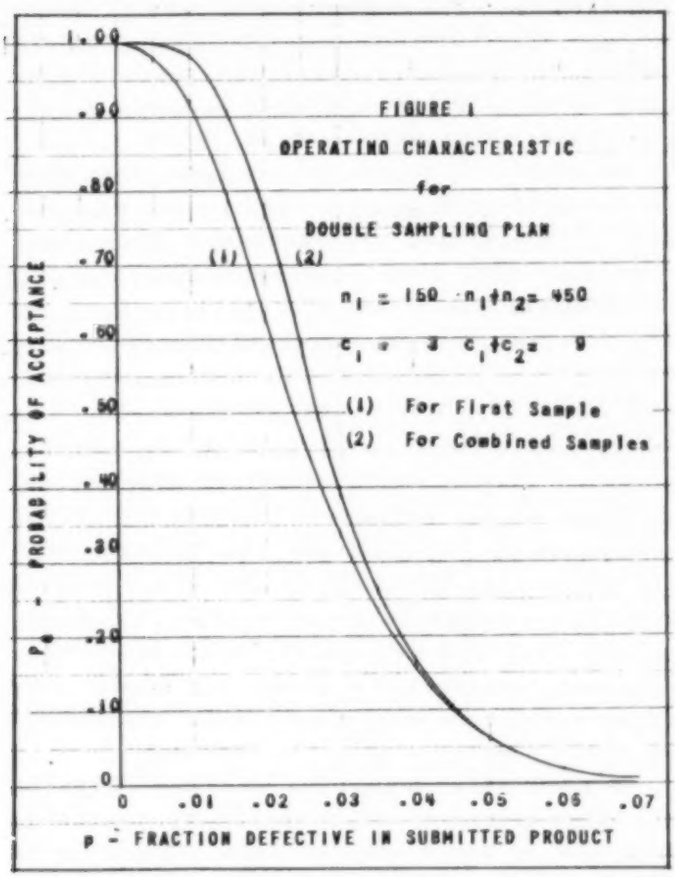


FIGURE I
OPERATING CHARACTERISTIC
for
DOUBLE SAMPLING PLAN
$n_1 = 150$ $n_1+n_2 = 450$
$c_1 = 3$ $c_1+c_2 = 9$
(1) For First Sample
(2) For Combined Samples
P_a - PROBABILITY OF ACCEPTANCE
p - FRACTION DEFECTIVE IN SUBMITTED PRODUCT

For the combined samples (n_1+n_2) of 450 pieces the total probability of acceptance (P_{a_2}) is equal to the probability of acceptance for the first sample (P_{a_1}) plus the sum of the probabilities of finding:

(1) Exactly 4 defects (P_{d_1}) in the first sample times the sum of the probabilities of finding 0 to 5 (P_{d_2}) defects in 2nd sample.

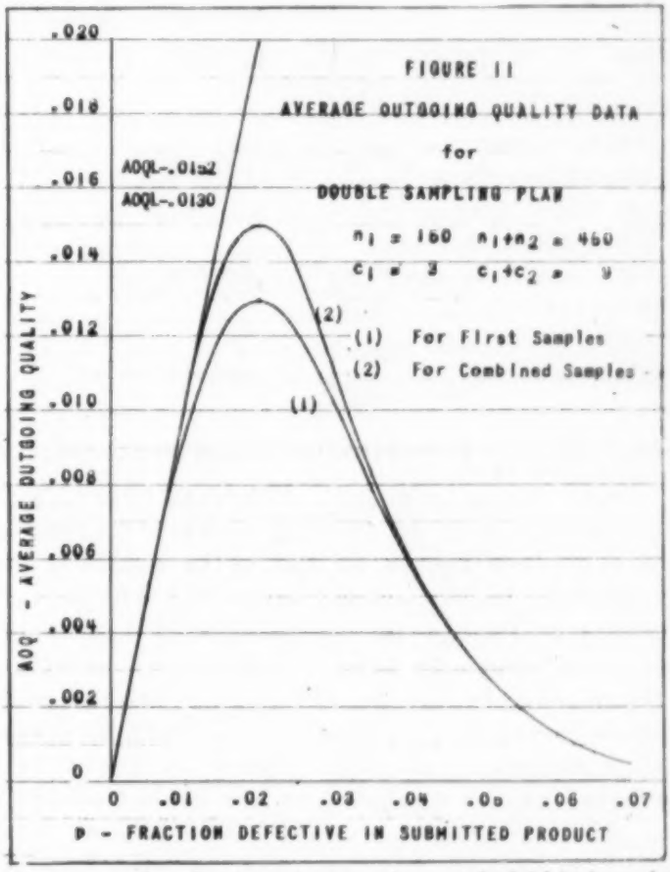
(2) Exactly 5 defects (P_{d_1}) in the first sample times the sum of the probabilities of finding 0 to 4 (P_{d_2}) defects in 2nd sample.

(3) Exactly 6 defects (P_{d_1}) in the first sample times the sum of the probabilities of finding 0 to 3 (P_{d_2}) defects in 2nd sample.

(4) Exactly 7 defects (P_{d_1}) in the first sample times the sum of the probabilities of finding 0 to 2 (P_{d_2}) defects in 2nd sample.

(5) Exactly 8 defects (P_{d_1}) in the first sample times the sum of the probabilities of finding 0 to 1 (P_{d_2}) defects in 2nd sample.

(6) Exactly 9 defects (P_{d_1}) in the first sample times the sum of the probabilities of finding 0 (P_{d_2}) defects in 2nd sample.



Since each of the above six probabilities is equal to:

(1) The probability (P_{d_1}) of finding exactly (d_1) defects in the first sample such as 4, 5, 6, 7, 8, or 9

Multiplied by

(2) The sum of the individual probabilities (P_{d_2}) of finding (d_2) defects in the second sample equal to the difference between the allowable total of 9 and the number found in the first sample.

The total probability becomes:

$$P_{a_2} = P_{a_1} + \sum P_{d_1} P_{d_2}$$

For example assume as above that (p) equals 0.02 and that (m) equals 7:

From(1) $P_{d_1} = P_{7,3} = \dfrac{e^{-3}(3)^7}{7 \cdot 6 \cdot 5 \cdot 4 \cdot 3 \cdot 2 \cdot 1} = .021604$

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If seven failures are found in the first sample, then two, one or no failures, may occur in the second sample.

From (2) $$P_{d_2} = \sum_{m=0}^{m=2} P_{m,6} = P0'6+P1'6 + P2,6 \qquad (5)$$

Then $$P_{0,6}=\frac{e^{-6}(6)^0}{1} = .002478$$

$$P_{1,6}=\frac{e^{-6}(6)^1}{1} = .014873$$

$$P_{2,6}=\frac{e^{-6}(6)^2}{2\cdot 1} = \underline{.044618}$$

Therefore $$P_{d_2} = \sum = .061969$$

and $P_{d_1}P_{d_2} = (.021604)(.061969)=.001339$

This value of $P_{d_1}P_{d_2} = .001339$ indicates the probability of finding exactly 7 defects in the first sample of 150 units and 2, 1 or 0 defects in the second sample of 300 units. Values of $P_{d_1}P_{d_2}$ may be calculated similarly for instances in which 4,5,6,7,8, or 9 defects are found in the first sample and corresponding (differences between maximum of 9 defects and those found in the first sample) values are found in the second sample.

For the example cited the sum of the $P_{d_1}P_{d_2}$ values equals .112736 and P_{a_2} = .647232 + .112736 = .759968.

Additional values of P_{a_2} may be calculated similarly for any value of fraction defective (p) by substituting the proper values in equation (4) above. Sufficient points should be determined in order that the final result will appear as the smooth line (2) of Figure (1).

As previously, the laborious work of the formula may be avoided by the use of the tables and curves. The value of P_{d_1} is found from Table I of Molina's Tables at the pn ("a in the terminology of the table) for the first sample and at the "x" corresponding to the number of failures found in the first sample. For the example assumed, p equals .02, n_1 equals 150, so pn equals 3; m equals 7. From Table I at a = 3 and x = 7, P_{d_1} = .021604 is found. This corresponds to the value calculated above. For the second sample, p equals .02, n_2 = 300, so pn equals 6. In Table I at a = 6, opposite x = 0, read .002479; opposite x = 1 read .014873; opposite x = 2 read .044618. These are the probabilities of finding 0, 1, or 2 failures in the second sample and correspond to the values calculated above. The summation of these figures is P_{d_2}. To avoid the work of summing up the individual probabilities, reference may be made to Table II of cumulated terms or to the cumulative probability curves.

Reference to Figure I indicates that when the fraction defective is small, the probability of acceptance (P_a) is large. This means that most lots submitted for inspection will be accepted and a few will be rejected. As the fraction defective increases more and more lots will be rejected for detailing and fewer and fewer lots will be accepted.

If there were no inspection the average outgoing quality would equal the fraction defective in the submitted product. This is indicated by the straight line of Figure II. If inspection is carried out according to plan the average outgoing quality decreases as the fraction defective increases. This decrease continues at a slower and slower rate as more and more lots are rejected and detailed until a maximum point is reached.

Beyond this point the average outgoing quality increases as a result of the rapid increase in the number of lots rejected with attendant detailing. This maximum point is designated as the Average Outgoing Quality Limit (AOQL), and is defined as that value which, on the average, will not be exceeded regardless of the level of defects in the product submitted for acceptance. The AOQL concept was developed because of the need for a plan which would evaluate average quality protection as compared with previous plans specifying lot tolerance and consumers risk. The AOQL concept is most useful also in comparing various plans of average quality protection.

In most sampling inspection plans defects when found are replaced. In certain instances however, it may be desirable to remove defects but not replace them. For the purpose of our discussion, however, it will be assumed that all defects are replaced in lots rejected for detailing. When this procedure is followed

(Continued on Page 10)

CONTROL CHART FOR DETERMINING TOOL WEAR

By

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The question is frequently asked, "Can the control chart be used for predicting tool wear". The control chart definitely can predict tool wear, provided it is so constructed as to make such information available. The control chart should be a complete log of the running of the job. It should show not only the quality of the parts being controlled, but it should also show all of the things that happened during the running of the job which in any way affect the production of the particular job-whether this affect be on the quantity made, the quality, the cost, or the tools being used.

It is assumed that when it is desired to obtain a prediction of tool wear, that such prediction is to be used for the purpose of obtaining maximum tool life. Therefore, it is desirable to know in which direction dimensions will drift as a result of tool wear-will dimensions get larger or smaller as a result of the breakdown of the cutting edge of the tool. It is important that this be determined at the outset. If such information is not available, a study of a conventional control chart will generally provide the answer.

Reference to Figure I will show that there is a definite trend in the direction in which dimensions will drift as the tool wears from hour to hour. This figure shows that at 4 P.M. on May 10, the form tool was ground and readjusted in the machine so that the average of five pieces was about .2477". Seven hours later - at 11 P.M. on May 10 - it was found that the machine was not running. However, we notice that the dimension of the parts has changed from an average of .2477" to .2487".

The machine was started again at 1 A.M. May 11, when the average for five parts was about .2481". The machine ran until 7 A.M., when it was stopped for adjusting the setup and oiling of the machine.

Up to this point, while there has been a definite trend in tool wear, the machine has been stopped and cutting tools adjusted before defective parts were produced. In both cases of stopping and readjusting the machine, at 11 P.M. and 7 A.M., the machine could have been allowed to run, since the tools were producing parts which were well within the specification limits. However, we can see that parts are becoming larger as the cutting tool wears.

At 9 A.M. on May 11, we note that "the form tool was adjusted". It was "ground" at between 2 P.M. and 3 P.M., and the machine readjusted toward the lower limit of the specification. The machine then ran continuously until about 9 P.M., when again "the form tool was ground".

It must be noted that the control limits for this chart are set at 3 standard deviations (3σ) inside of each specification limit. That is, the upper control limit is set at a distance of 3 standard deviations below the upper specification limit, and the lower control limit is set at 3 standard deviations above the lower specification limit.

These control limits are derived from frequency distribution analysis. At any time the pieces coming from the machine vary in accord with the constant cause system of the process. If 50 consecutive pieces are measured, the measurements will distribute themselves in the form of a frequency curve as shown at the left of Figure I. The standard deviation of this distribution is .00021. Hence the tolerance of the process is $6 \times .00021 = .00126$. Since the distribution is nearly symmetrical, it is to be expected that at any time parts will be produced at a distance of 3σ on either side of the average. Therefore the production of rejects will be avoided by adjusting the process when the average of five pieces reaches the upper control limit which is drawn .00063 below the upper specification limit. Individual measurements will appear above the control limit. The combination of points above the control limit and average approaching the control limit gives the signal to shut down the machine and readjust toward the lower control limit.

It must be noted that while there is a definite trend upward in the dimension, as a result of tool wear, this trend is gradual and not sudden. Any sudden change upward, or downward, in the location of the five points

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designating the five measurements on a sample of five pieces, should be taken as indicative of complete failure of the tool edge. Such a condition should be investigated immediately.

The tool-wear cycle of this operation has been established at seven hours, hence the toolsetter tends this machine at seven hour intervals. But the charts and the hourly samples are maintained to protect against any unexpected process deviation and to provide a continuous record of everything that occurred while the job was running.

Often times, too much stress is placed on the "skewness" of the distribution of the original sample of fifty pieces used for determining the control chart. Reference to Figure I will show that the original distribution was somewhat skewed, but that it was possible to control this operation from 5 P.M. May 10 until 10 P.M. May 11 without producing defective parts. We are interested in producing parts which fall within specification limits and, therefore, we are not too much concerned with the type of distribution obtained.

For those who prefer it, there is an alternate procedure available which eliminates this residual skewness. This method estimates standard deviation through range. For the thirty sub-groups of 5 measurements shown on Figure I the average range is .00044. Using the formula

$$\sigma' = \frac{\bar{R}}{d_2} = \frac{.00044}{2.326} = .00019$$

in the notation of the American Standards Pamphlet, Z 1.3, gives an estimated standard deviation of .00019. The control limits would then be set in .00057 from the specification limits. The difference in practice is nominal, although it is true that the smaller standard deviation may give a better basis for estimating the natural tolerance of the process. Particularly with a short tool-wear cycle, the effect of wear will show up in the form of skewness when a distribution of 50 or 100 pieces is used to compute standard devi-

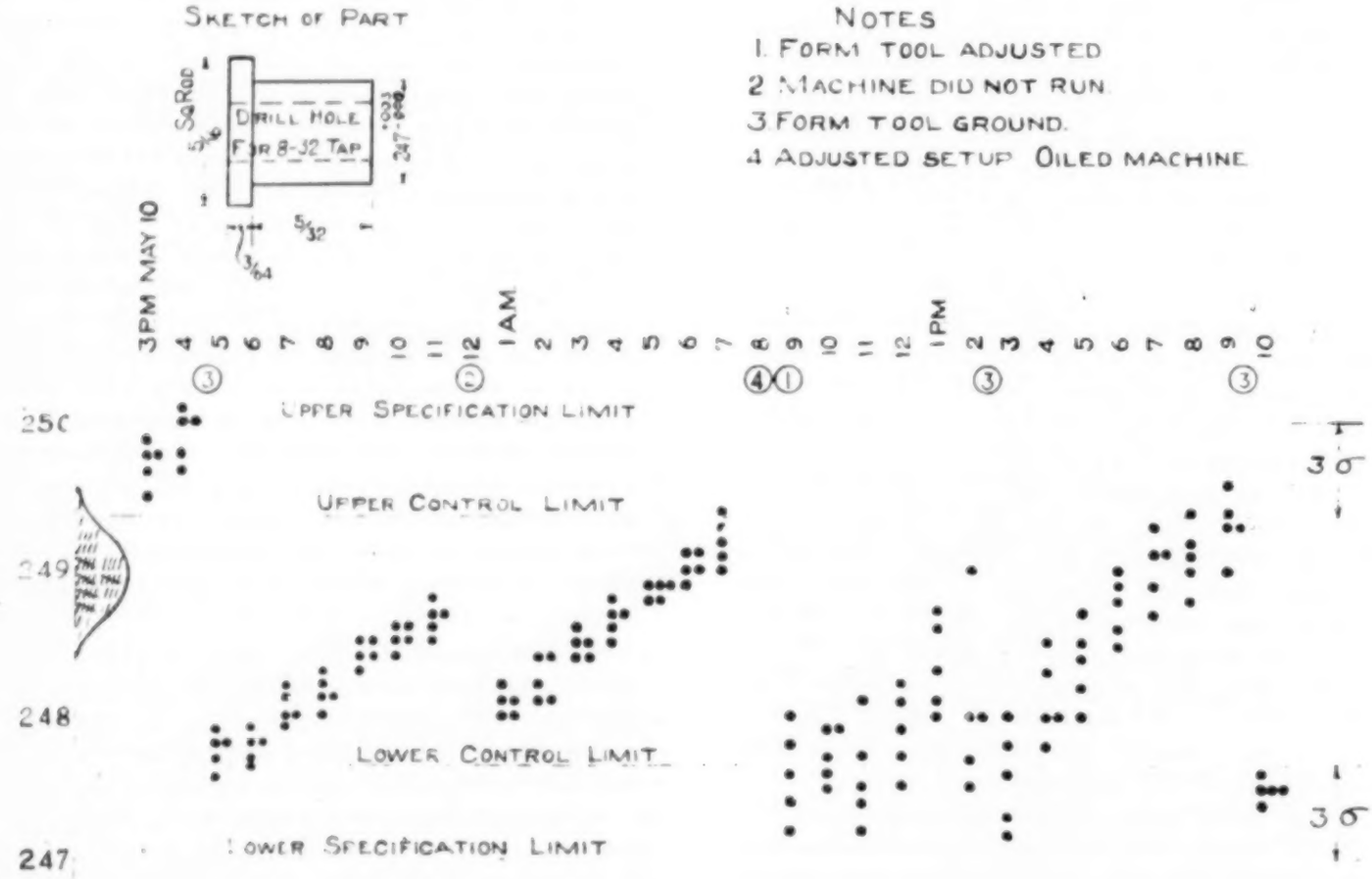

FIGURE I

ation. The result is some overestimate of the variability.

It will be noted that the inspector allowed the operation to get out of control at 3 P.M. on May 10, and that he found defective parts at 4 P.M. when he made his next inspection of the operation. Readers should also note that at 8 A.M. May 11 the tool setter did not get his usual precision. The variability for the next six hours was larger than usual, and the process did not really settle down during the following seven hour cycle.

Figure II shows a similar control chart also used for predicting and controlling tool wear. It will be noted that the "runs" in this case are longer than those shown in the previous chart. Whereas tool life shown in Figure I averaged about seven hours, in Figure II tool life is about twenty-one hours. The length of tool life is determined by many factors - such as -

(a) Material of which the tool is made.
(b) Material being worked upon by the tool.
(c) Speed and feed in removing metal.
(d) Type and amount of coolant used.

This chart is prepared like the first one. The 3 σ control limits are based on previous records. The lines drawn through the plotted points show how the pieces are being produced as the tools gradually wear and the diameters of the pieces increase toward the plus tolerance.. On this job the tool wear seemed to follow a curved pattern, although the tendency could not be detected in the lower half of the chart. The center or average line is drawn free hand through the averages of the samples of five, or a more accurate determination can be made by the method of least squares. The variability lines are then entered as indicated at the left of the chart.

As soon as enough information has been plotted on the chart to permit the construction of the variability pattern the tool-wear cycle is fully determined. The time at which the $\pm$ 3 σ curve intersects the plus tolerance marks the place for shutting down the machine. This is, of course, the time at which the average line intersects the upper control limit.

The variability pattern permits an addit-

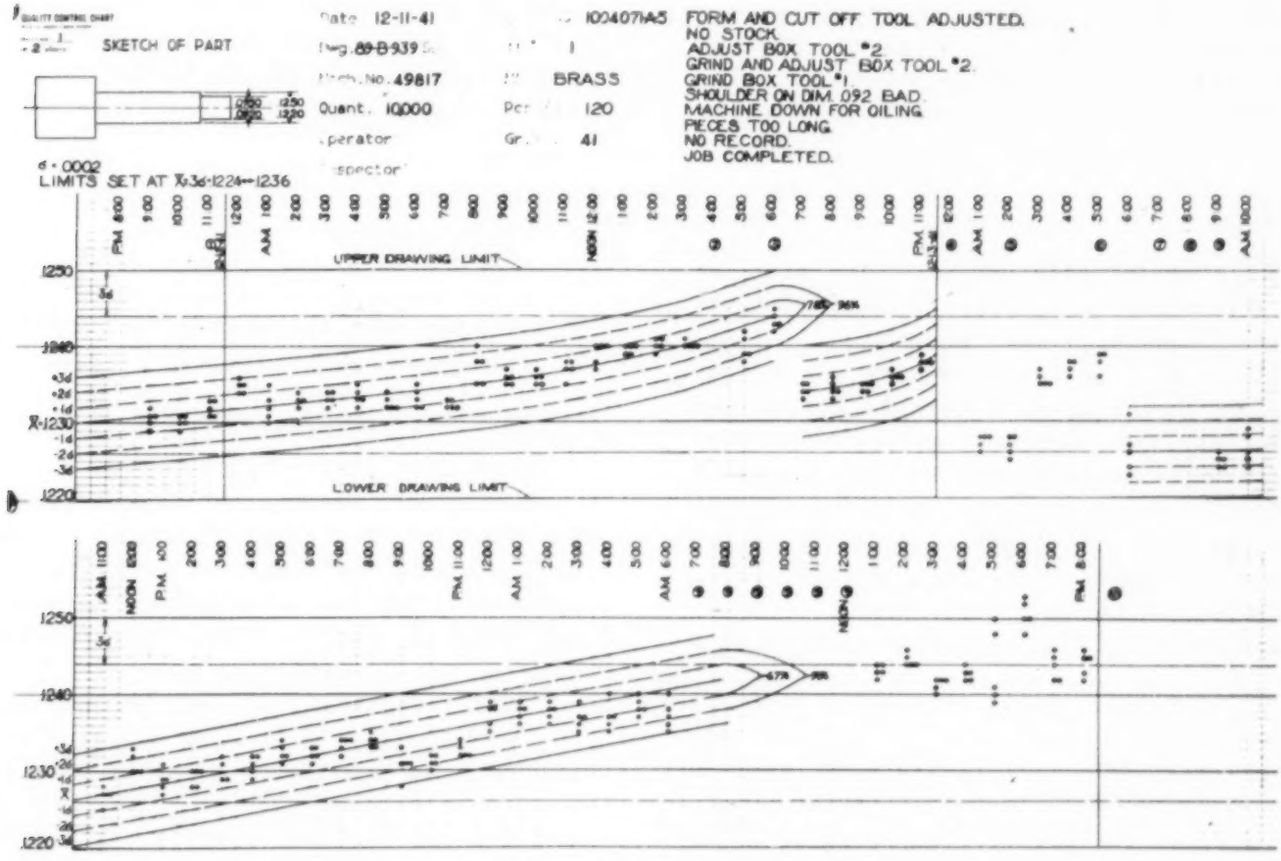

FIGURE II

ional check on the behavior of the process. At the end of a tool-wear cycle count the number of measurements falling within each band. The following tabulation shows how the points should be distributed compared with the actual.

Limits	Theoretical %	1st Cycle %	2nd Cycle %
$\pm\ \sigma$	76.6	78	67
$\pm\ 2\sigma$	98.3	96	91
$\pm\ 3\sigma$	100.0	100	99

During the first cycle the process behaved very well, but evidence of impending trouble appears in the second cycle. This difficulty came to a head at 6 P.M. December 13 and would have required major attention to the process except for the fact that the job was nearly completed. In this case the production of the last four hours was inspected in detail.

This matter of detailing parts brings up a general question. The methods described in this article are set up so that 100 percent inspection can be avoided as far as possible. Things can and do go wrong with machine processes, and at such times parts are made which are outside of specification limits, and detailing is necessary. But we try to operate these charts so as to maintain finger-tip control which will avoid such contingencies as far as possible. That is the reason for putting the control limit 3 standard deviations inside the specification limits. In so doing the tool-wear cycle may be cut off a little short of the full possibilities. But this is considered to be a lesser evil than the chance that by running closer to the specification limit sufficient oversize pieces will be made to force screening of several hours' production.

Each quality control operator must decide this question for his own operations in terms of cost of inspection and cost of rework, versus the cost of maintaining sensitive process control of the type presented here. Certainly there are circumstances in a plant which make it desirable to allow a tooling set up to run beyond the limits indicated by the chart, but operators will do well to oppose the growth of habits in the plant which permit such occurrance to become chronic.

Finally, we have taught tool setters in all cases to adjust a new set up to produce near the lower control limit (upper limit for internal dimensions). This question was settled originally with the tooling department by presentation of data showing the loss of money due to time the machines were out of production when set up men worked to the drawing dimension instead of the tolerance limit.

ANALYSIS OF DOUBLE SAMPLING PLAN

(Continued from Page 6)

defective items will be included only in those lots which are accepted in accordance with the inspection plan adopted.

If lots of fraction defective p are submitted for inspection, a certain percentage will be accepted depending on the particular sampling plan employed and will be equal to the probability of acceptance P_a corresponding to the value of p chosen. This value may be found by referring to the operating characteristic curve and reading the value P_a corresponding to the particular value of p involved.

Since defective items will have been replaced in all rejected lots, it follows that the fraction defective in all lots will be equal to the fraction defective in the accepted lots times the probability of acceptance. Therefore, the average outgoing quality is given by the equation

$$AOQ = pP_a \qquad (6)$$

For example if $p = .014$ and $P_a = .944740$

$$AOQ = .014 \cdot .944740 = .01323$$

This value may be found from (2) of Figure II.

Having once determined the operating characteristics of a sampling plan such as described above, it becomes a relatively simple matter to find the relationship between average outgoing quality (AOQ) and fraction defective (p) in submitted product.

Substituting values of p vs Pa_1 and p vs P_{a_2} in Equation (6) results in values of average outgoing quality vs fraction defective in submitted product both for the first sample and for the combined samples. These results as shown graphically by curves (1) and (2) of Figure II. The value of p for which the

(Continued on Page 20)

A COMPARISON OF ACCEPTANCE INSPECTION PLANS

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I. INTRODUCTION

In a discussion of acceptance inspection plans three comparisons suggest themselves. First, we may compare single sampling with double sampling. Second, we may compare the Army Ordnance Tables with those by Dodge and Romig. Third, we may compare single and double sampling plans with sequential plans.

II. SINGLE SAMPLING vs. DOUBLE SAMPLING

Single sampling plans have the advantage of simplicity, and if properly designed are about as effective as double sampling plans. Another way of stating this fact is that for any given double sampling plan it is possible to find a single sampling plan which will have very nearly the same operating characteristic.

Double sampling plans are generally preferred in spite of their greater complexity, and this for two reasons. In the first place, double sampling plans have a better psychological appeal; the idea of giving the material a second chance if it fails on the first trial conforms to most people's sense of reasonableness. Actually, the second sample in a properly designed plan is not a concession at all. In double sampling plans the standard for passing on the first sample is set high. The second sample provides enough relaxation to bring the over-all operation of the plan down to the desired level. The net result is to equalize the operation of the single and double sampling plans. Nevertheless, human nature being what it is, the taking of a second sample has a certain appeal and is a valid reason for preferring double sampling.

Another reason is that a double sampling plan automatically adjusts the amount of inspection to the quality of the material inspected. Lots of very high quality are usually accepted on the first sample. As incoming quality deteriorates the number of second samples required increases so that for poor quality practically every lot will be judged on the basis of two samples. Consider a single sampling scheme calling for a sample size of 100. The amount of inspection will be uniform for all incoming quality; regardless of whether the lot is good or bad we examine 100 pieces. A double sampling plan with a similar operating characteristic might call for a first sample of 50 and a second sample of 100. Lots of high quality would then be accepted on 50 pieces only, or half as much inspection as called for by the single sampling plan. For lots of poor quality we might have to take a second sample all the time, thus inspecting a total of 150 pieces per lot, or 50% more than called for by single sampling. Somewhere in between there would be a lot quality that would call for passing about half the lots on the first sample and resampling the remaining half. For such quality the average amount of inspection would be 100 pieces per lot, the same as for single sampling.

To sum up, we may say that when practical considerations give us a free choice between single and double sampling the advantage will usually lie with double sampling due to its greater psychological acceptability and to the fact that for better quality material it calls for less inspection.

Both single and double sampling can be made more efficient by using curtailed inspection. This simply means that inspection ceases as soon as the maximum number of allowable defects has been exceeded, even though a portion of the sample remains uninspected. Suppose we have a single sampling plan that calls for a sample size of 100 and a maximum of 5 defects allowable. Suppose also that as we inspect a particular sample we find 6 defects in the first 50 pieces examined. Using curtailed inspection we would reject the lot at once, without looking at the remaining 50 pieces of the sample. In this way the amount of inspection required diminishes for lots of extremely poor quality since we very quickly accumulate enough evidence to reject them.

Curtailment can be used with double sampling, and by means of a suitable device can provide considerable economy in inspection. Suppose that our double sampling plan has acceptance numbers 3 (for the first sample) and 9 (for the combined samples). If we find

10 defects in the first sample there is clearly no point in taking the second sample. Suppose that we find 8 defects in the first sample, is there any point in taking a second sample then? Even without figuring the exact chances most inspectors would probably say no. As it works out, if we have sample sizes of 50 and 100 with acceptance numbers 3 and 9, there is little to gain from a second sample if we find as many as 6 defects in the first. By calculating a set of rejection numbers for first samples the need for taking second samples can be reduced considerably for poor quality lots.

The advantages of curtailed inspection are not obtained without some sacrifice. Any inspection plan that calls for complete inspection of a sample of predetermined size can be used in conjunction with a control chart. The observed number of defects can be plotted on the chart and since the sample size is uniform we are able to construct control limits. With curtailed inspection this ability is lost. Since we stop inspection as soon as we have passed the maximum allowable defect number, the sample size measured by pieces actually examined will be variable. If this were the only difficulty we might still make a control chart using variable limits, but this possibility is shut out by the fact that our sample size and the number of defects observed are tied together by our method of inspection. In curtailed inspection the last piece examined is always a defective.

The ability to maintain a control chart on acceptance inspection is extremely valuable and should not be sacrificed without a full understanding of what is being lost. Fortunately a compromise is possible through which we retain the control chart and at the same time keep much of the economy of curtailed inspection. If we adopt a double sampling scheme and require <u>complete</u> inspection of all <u>first</u> samples we may then set up first sample rejection numbers and also use <u>curtailed</u> inspection on <u>second</u> samples. The control chart is always based on first samples only, and thus is not affected by using curtailed inspection on second samples.

III. ARMY ORDNANCE TABLES vs. DODGE AND ROMIG

To the casual eye the sampling tables published by Army Ordnance and those given by Dodge and Romig seem pretty much alike. This similarity is an illusion; actually the two systems are strongly unlike.

Dodge and Romig give a set of tables for "lot quality protection". For each of these tables there is a quality level called the "lot tolerance percent defective." The Army Ordnance tables are entered with an "acceptable quality level", but this is not the same as the Dodge-Romig "lot tolerance percent defective". The Army Ordnance figure is intended to be accepted and the tables are calculated in such a way that lots of barely acceptable quality will pass inspection about 95% of the time. The Dodge-Romig percentage is treated as an undesirable quality level and the tables are calculated to reject all such quality 90% of the time. If the percentage in question is taken as the specification quality we have here opposite points of view; Ordnance takes the position that such material should be accepted, and Dodge-Romig that it should be rejected.

The preceding remarks apply to the SL and DL tables in the Dodge-Romig series. The SA and DA tables are based on some fixed value of the "AOQL" or "average outgoing quality limit". Under certain conditions these tables are more nearly comparable with the Ordnance tables, but the conditions are by no means always satisfied. A little thought will show why this is true.

The AOQL tables require that each rejected lot should be 100% inspected and completely cleared of defectives, or, in different words, that each rejected lot be replaced by a perfect lot. When this procedure is carried out the percentages at the head of the SA and DA tables have a meaning. If this procedure is not carried out the percentage figures have no meaning.

A little reflection will suggest a number of situations in which the procedure cannot be carried out.

1. The method has not been designed for use when inspection is destructive. In this case there can obviously be no 100% inspection.

2. The method fails when the supplier instead of reworking rejected material has the alternative of resubmitting as a lower grade or sending it to another buyer. Here the dilution of defectives by reworked material does not take place.

3. The method may fail if the supplier does not do a conscientious and thorough job of reworking.

4. The method is only partially successful in cases when the process average, though outside tolerances, is still very low. When defectives are very infrequent 100% inspection is unreliable.

5. The method is impracticable when the cost of inspecting a piece is high as compared with its purchase price. In such cases it would be cheaper to throw the lot away than to rework it.

6. The method fails for unique lots, and is of doubtful utility when long intervals occur between successive lots.

When the AOQL procedure is carried out correctly the DA tables of Dodge and Romig are roughly comparable with the Ordnance double sampling tables, the latter being entered through the AOQL column. Unfortunately the situations in which the AOQL inspection is not performed are rather numerous, and using the Dodge-Romig SA and DA tables in such instances is incorrect.

The Dodge-Romig tables are said to provide a minimum amount of inspection. This is true if, and only if, AOQL inspection is correctly carried out. When it cannot be carried out not only do the Dodge-Romig tables lose their quality of minimizing the amount of inspection; the SA and DA tables lose their very meaning.

The Army Ordnance tables are to some extent arbitrary. For example, there is no special mathematical justification for having the second sample always double the first; the Ordnance tables here make a concession to convenience and custom. The relation of sample size to lot size is also arbitrary. The choice of producer's risks for major and minor defectives may be reasonable but still has an element of arbitrariness which is increased by the necessary arbitrariness of definition distinguishing major and minor defects. The conditions for passing to reduced inspection are arbitrary. Nevertheless, if we are to have such tables at all, it is clear that choices have to be made and such choices must often be arbitrary. The Ordnance choices appear reasonable to the writer.

The Army Ordnance tables are largely arbitrary. There is no mathematical justification for having the second sample always double the first; the Ordnance tables here make a concession to convenience and custom. The relation of sample size to lot size is also arbitrary. The choice of producer's risks for major and minor defectives may be reasonable but still has an element of arbitrariness, which is increased by the necessary arbitrariness of definition distinguishing major and minor defects. The conditions for passing to reduced inspection are arbitrary. Of course, if we are to have such tables at all, it is clear that choices have to be made and such choices must often be arbitrary. Whether the Ordnance choices are good is a question that calls for a better mathematical analysis than has yet been published; preliminary studies by the writer suggest that the amount of inspection called for by the Ordnance tables is excessive.

Both the Ordnance and the Dodge-Romig tables provide for reduced inspection under certain conditions. The Dodge-Romig tables provide six different levels, the Ordnance tables two. As a matter of practical administration and supervision the two-level scheme seems preferable. The specification percentage set up in Army Ordnance as a quality to be accepted conforms to good business usage. It is more agreeable to suppliers who are interested in what the customer will accept rather than what he is bent on rejecting. The Ordnance tables cover fewer pages and are easy to understand and use; the Dodge-Romig tables, if for no other reason than their bulk, involve greater risks of misuse. The chief merit of the Dodge-Romig tables, that they provide minimum inspection, disappears if AOQL procedures are not carried out. There remains a field in which the Dodge-Romig tables are superior, but this field by no means includes all inspection situations.

The Ordnance and Dodge-Romig tables are equally suited for use in connection with control charts, but it is the writer's feeling that the Ordnance tables come closer in spirit to the control chart method, and that this method more than any sampling scheme can provide a sound basis for the purchase and acceptance of materials continuously received. It is applicable to inspection by variables as well as attributes. It is capable of being carried out with a relatively small amount of inspection. In the final analysis neither the Ordnance tables, the Dodge-Romig tables nor any other scheme can be entirely relied upon to separate good lots from bad, or to

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accept good lots if only bad ones are submitted. Good quality in incoming materials can be assured in one way and one way only, to buy from a supplier who makes only good product. Such suppliers can be recognized by the control chart method.

IV. DOUBLE SAMPLING vs. SEQUENTIAL SAMPLING

Information on sequential analysis is restricted, and this discussion must therefore omit references to the details of sequential methods. It is still possible to say a few words by way of comparison. Sequential inspection has the merit that for a given operating characteristic it provides very nearly a minimum amount of inspection. This is a different kind of minimum from the Dodge-Romig minimum; whereas Dodge and Romig assume AOQL inspection, sequential analysis does not. It is true that sequential methods can be used in conjunction with AOQL inspection but if they are, the total amount of inspection may in some cases exceed that called for by Dodge and Romig, due to the greater frequency of rejection of substandard lots. If no AOQL is contemplated then sequential analysis does provide more economical inspection than either Army Ordnance or Dodge-Romig. This is true even when reduced inspection is used because in such instances the sequential scheme can be redesigned to provide the same operating characteristic with still less inspection.

An important advantage of sequential methods as presented today is that they stress the need for setting up two points on the operating characteristic. There is no reason why this approach could not be used with double sampling and single sampling, and it is the writer's strong conviction that it should be. The inspection manual of the future should provide an assortment of operating characteristics and give single sampling, double sampling and sequential schemes corresponding to each one.

Sequential analysis has two serious drawbacks. In the first place, it is, relatively speaking, complicated. The complexities of supervision and administration cannot be ignored as a partial offset to the saving in amount of inspection. In the second place, sequential methods do not combine readily with chart control due to the constantly fluctuating amount of inspection performed.

Even the economy feature of sequential analysis can be exaggerated. Neither Army Ordnance nor Dodge and Romig carry the minimization of inspection as far as it could be carried with double sampling. Of course double sampling could hardly be made as efficient as sequential sampling in the very nature of things, but in making our comparisons we should not assume that existing schemes of double sampling have reached the limit of possible efficiency. Mention has been made of curtailed inspection by means of which material savings can be made with either single or double sampling, especially if we are willing to forego the advantage of a control chart.

V. SUMMARY

Of the inspection schemes at present available, no one can be selected as unqualifiedly best. In making a choice the following considerations may perhaps be helpful:

1. When inspection is very costly it may be desirable to use sequential sampling even if this calls for hiring a professional statistician.

2. When AOQL inspection is correctly carried out the Dodge-Romig tables are appropriate. In this case sequential methods offer little or no economy except for high incoming quality levels.

3. When AOQL inspection is not carried out the Army Ordnance tables will often be preferred because of their simplicity and to ease with which they lend themselves the chart control.

4. The only way to be sure of accepting only good product is to purchase from a supplier who makes only that kind. In the long run the use of a control chart and cooperative work on quality between the supplier and the customer hold out better promise for quality improvement than any set inspection plan.

JUNE MEETING OF S.Q.C.E.

Plans are being made for a dinner meeting of the Buffalo Society to be held the middle of June. A speaker prominent in the field of Quality Control will be present. Regular notice of meeting telling of the time and place will be mailed to all our members in sufficient time to plan to attend this meeting. As always, guests are welcome.

USE OF A TABLE OF AREAS OF THE NORMAL CURVE IN QUALITY CONTROL WORK

By

Martin A. Brumbaugh

A satisfactory machine set-up will produce piece parts with an inspection record that meets three requirements: the measurements are in control, the average is at the drawing dimension, the variability is consistent with the drawing tolerances. The third requirement is checked in a given case by comparing 6 standard deviations of individual measurements with the distance between the plus and minus tolerance limits. If the distance between the specification limits is equal to or greater than 6 σ and the average of the measurements lies nearly midway between the tolerances little or no scrap will be produced.

If this condition is not met, scrap or rework and repair will result. With the aid of a table of areas of the Normal Curve the percentages of rejectable material can be predicted very closely. This is an important advantage to the Quality Control operator because it allows him to estimate the cost of rejections on a job and therefore to determine how much can be spent to get corrective action on the fault or faults involved.

The procedure is shown in connection with the following example. The piece part is a metal cylinder which is assembled in a thermostatic control mechanism. The operation is the grinding of the outside diameter of the cylinder and the dimension is 1.9995" ± .0005". Samples of 5 cylinders were measured at twenty minute intervals. The averages and ranges of 24 samples are given in Table I. The average is 1.99944 and the range is .00076. A control chart of this record does not show a state of control of either the averages or the ranges, hence the steps which follow are somewhat approximate, but not to an extent which will seriously affect the conclusions. According to this sample the variability of the process is,

$$\sigma = \frac{\bar{R}}{d_2} = \frac{.00076}{2.326} = .00033; \quad 3\sigma = .00099$$

and

$$\bar{\bar{X}} + 3\sigma = 2.00043; \quad \bar{\bar{X}} - 3\sigma = 1.99845$$

This means that parts are being produced above the high tolerance and below the low tolerance, although the average is very close to the drawing dimension. The variability of the process is excessive. The parts that are oversize can be reground but those that are undersize must be scrapped.

The table of Areas can be used to determine the percentage of rework and scrap.

TABLE I: AVERAGES AND RANGES OF SAMPLES OF 5 MEASUREMENTS OF THE DIAMETER OF A CYLINDER.
DRAWING DIMENSION = 1.9995" ± .0005"

SAMPLE NO.	AVERAGE	RANGE	SAMPLE NO.	AVERAGE	RANGE	SAMPLE NO.	AVERAGE	RANGE
1	1.9990	.0007	9	1.9996	.0007	17	1.9999	.0002
2	1.9989	.0012	10	1.9995	.0005	18	1.9996	.0007
3	1.9993	.0004	11	1.9995	.0012	19	1.9997	.0010
4	1.9988	.0008	12	1.9998	.0003	20	1.9993	.0010
5	1.9988	.0009	13	1.9997	.0007	21	1.9997	.0008
6	1.9991	.0015	14	1.9999	.0003	22	1.9994	.0004
7	1.9998	.0007	15	1.9997	.0007	23	1.9993	.0006
8	1.9998	.0004	16	1.9991	.0020	24	1.9995	.0006

REWORK

$$\frac{x}{\sigma} = \frac{2.0000 - 1.99944}{.00033} = \frac{.00056}{.00033} = 1.70$$

Enter Table II at 1.7 on the left and 0 at the top. Read .455435. This value subtracted from .500000 gives .044565, the fraction of production which will measure more than the high tolerance. That is, about 4.5 percent of the cylinders will require rework.

SCRAP

$$\frac{x}{\sigma} = \frac{1.99944 - 1.9990}{.00033} = \frac{.00044}{.00033} = 1.33$$

Enter Table II at 1.3 on the left and 3 at the top. Read .408241. This value subtracted from .500000 gives .091759, the fraction of production which will measure less than the low tolerance. That is, about 9.2 percent of the cylinders will be scrap.

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TABLE II: AREAS OF THE NORMAL CURVE

$\frac{x}{\sigma}$	0	1	2	3	4	5	6	7	8	9
0.0	000000	003989	007978	011967	015953	019939	023922	027903	031881	035856
0.1	039828	043795	047758	051717	055670	059618	063560	067495	071424	075345
0.2	079260	083166	087064	090954	094835	098706	102568	106420	110261	114092
0.3	117911	121720	125516	129300	133072	136831	140576	144309	148027	151732
0.4	155422	159097	162757	166402	170031	173645	177242	180823	184386	187933
0.5	191463	194974	198468	201944	205402	208840	212260	215661	219043	222405
0.6	225747	229069	232371	235653	238914	242154	245373	248571	251748	254903
0.7	258036	261148	264238	267306	270350	273373	276373	279350	282305	285236
0.8	288145	291030	293892	296731	299546	302338	305106	307850	310570	313267
0.9	315940	318589	321214	323815	326391	328944	331472	333977	336457	338913
1.0	341345	343752	346136	348495	350830	353141	355428	357690	359929	362143
1.1	364334	366501	368643	370762	372857	374928	376976	379000	381000	382977
1.2	384930	386861	388768	390651	392512	394350	396165	397958	399727	401475
1.3	403200	404902	406583	408241	409877	411492	413085	414657	416207	417736
1.4	419243	420730	422196	423642	425066	426471	427855	429219	430563	431888
1.5	433193	434478	435745	436992	438220	439429	440620	441792	442947	444083
1.6	445201	446301	447384	448449	449497	450529	451543	452540	453521	454486
1.7	455435	456367	457284	458185	459071	459941	460796	461636	462462	463273
1.8	464070	464852	465621	466375	467116	467843	468557	469258	469946	470621
1.9	471283	471933	472571	473197	473810	474412	475002	475581	476148	476705
2.0	477250	477784	478308	478822	479325	479818	480301	480774	481237	481691
2.1	482136	482571	482997	483414	483823	484222	484614	484997	485371	485738
2.2	486097	486447	486791	487126	487455	487776	488089	488396	488696	488989
2.3	489276	489556	489830	490097	490358	490613	490863	491106	491344	491576
2.4	491803	492024	492240	492451	492656	492857	493053	493244	493431	493613
2.5	493790	493963	494132	494297	494457	494614	494766	494915	495060	495201
2.6	495339	495473	495604	495731	495855	495975	496093	496207	496319	496427
2.7	496533	496636	496736	496833	496928	497020	497110	497197	497282	497365
2.8	497445	497523	497599	497673	497744	497814	497882	497948	498012	498074
2.9	498134	498193	498250	498305	498350	498411	498462	498511	498559	498605
3.0	498650	498694	498736	498777	498817	498856	498893	498930	498965	498999
3.1	499032	499065	499096	499126	499155	499184	499211	499238	499264	499289
3.2	499313	499336	499359	499381	499402	499423	499443	499462	499481	499499
3.3	499517	499534	499550	499566	499581	499596	499610	499624	499638	499651
3.4	499663	499675	499687	499698	499709	499720	499730	499740	499749	499759
3.5	499767	499776	499784	499792	499800	499807	499815	499822	499828	499835
3.6	499841	499847	499853	499858	499864	499869	499874	499879	499883	499888
3.7	499892	499896	499900	499904	499908	499912	499915	499918	499922	499925
3.8	499928	499931	499933	499936	499939	499941	499943	499946	499948	499950
3.9	499952	499954	499956	499958	499959	499961	499963	499964	499966	499967
4.	499968	499979	499987	499992	499995	499997	499998	499999	499999	499999
5.	499999713									

In general, there are three cases to consider: (1) rejects at both tolerances, (2) rejects at the high tolerance only, (3) rejects at the low tolerance only. The previous example illustrates the first case. It arises from excessive variability of the process. Cases (2) and (3) may arise from incorrect average or a combination of incorrect average and excessive variability. Illustrations of these two cases follow.

AVERAGE HIGH

Dimension: 2.000" ± .015"

Data: Average 2.011: average range = .012, Sample Size 5

Rework: $\frac{x}{\sigma} = \frac{2.015 - 2011}{.0052} = \frac{.004}{.0052} = .77$

Fraction above average that are acceptable (Table II) is .27935.

Fraction rejectable: .5 - .27935 = .22065 or 22%.

Scrap: $\frac{x}{\sigma} = \frac{2.011 - 1.985}{.0052} = \frac{.026}{.0052} = 5$

Fraction below average that are acceptable (Table II) is .4999997.

Fraction rejectable: .5 - .4999997 = .0000003 or .00003%

AVERAGE LOW

Dimension: .500 + .005, -000

Data: Average .5005; Average Range .0025; Sample Size 5

Rework: $\frac{x}{\sigma} = \frac{.505 - .5005}{.00107} = \frac{0045}{.00107} = 4.2$

Fraction acceptable: .49999

Fraction rejectable: .000001 or .001%

Scrap: $\frac{x}{\sigma} = \frac{.5005 - .500}{.00107} = \frac{.0005}{.00107} = .47$

Fraction acceptable: .1808

Fraction rejectable: .3192 or 32%

These examples are set up on the assumption that the dimension referred to is an outside cut of some kind. If the dimension is a bore, internal thread etc. the use of the Area table is identical but the pieces outside the high limit are scrap and those outside the low limit can be reworked.

SOCIETY REPORTS

EDITOR'S NOTE: Due to the lack of space the names of the secretaries and their addresses are not shown. These are on file with the editor and will be supplied upon request.

CHICAGO SOCIETY FOR QUALITY CONTROL

As of April 22, 1945 there are 61 members of the Chicago Society who meet monthly to discuss various aspects of Quality Control. The Society is under the guidance of its president, Mr.. Warren E. Jones. Mr. Frederick Trowbridge, the program chairman, has brought to the Chicago Society interesting and well rounded meetings. These meetings discussed the statistical approach to problems relating to telescoping antennae and the accuracy and reproducibility of measurements. The problem of inspection by attributes or variables was presented. A paper relating to the bearing industry and one involving the practical uses of specification and control limits came up for discussion. Mr. Trowbridge found it necessary to resign his chairmanship because of the pressure of other duties. Mr. C. W. Richard succeeded Mr.. Trowbridge and brought before the March meeting speakers from the steel, aircraft, and pharmaceutical industries.

OHIO QUALITY CONTROL SOCIETY

At a March 28, 1945 meeting the Ohio Society adopted a constitution and elected the following officers: president, Mr. Wade Weaver of Republic Steel Corporation; vice president, Mr. Carl Apthorp of Cleveland Twist Drill Company; secretary, Mr. P. H. Hardy of General Electric Company; treasurer, Mr. Richard Schager of Cleveland Graphite Bronze. Mr. Robinson of the Cleveland Ordnance District spoke on sampling inspection plans.

QUALITY CONTROL ENGINEERS OF ROCHESTER

The monthly meeting of the Society was held April 24 when 221 members and guests heard Mr. Charles R. Scott, Jr. Supervisor of Quality Control, S.K.F. Industries, Philadelphia, Pennsylvania. Mr. Scott's subject "General Methods of Quality Control at S.K.F." was ably presented and drew numerous questions. His description of the process control points, the techniques which are used in controlling quality in ball bearing manufacture, were most instructive.

The next general meeting will be held May 29 with Mr. Ralph Wareham, General Electric Company as speaker. As an outgrowth of the Quality Control Clinic, a sub-group on Gage Control has been organized. This group of 30 men met April 3 and elected Mr. George Roth, Assistant Chief Inspector, General Railway Signal Company Chairman. The sub-group will meet monthly and is an integral part of the larger organization.

SYLVANIA ELECTRIC PRODUCTS COMPANY, INC.

Quality Control representatives of several of Sylvania's radio tube plants and a number of guests met April 18 at Emporium, Pennsylvania to discuss mutual problems and to listen to informal talks. During the course of the day talks were given by: Mr. A. N. Elmer on "The Organization and Operation of a Material Inspection Department"; Mr. Sidney Margolis on "The Functioning of a Quality Control Organization in a Radio Transmitting Tube Manufacturing Plant"; Mr. W. A. Weiss on "A Comparison of Double Sampling and Sequential Sampling Plans as Applied to Finished Tube Inspection"; and Mr. P. H. Sassaman on "The Application of Sequential Analysis to Incoming Material Acceptance".

A course for Quality Control and Engineering personnel is being given at the Danvers, Massachusetts plant and an advanced course covering analysis of engineering data is being conducted at Williamsport, Pennsylvania.

INDIANA SOCIETY FOR STATISTICAL QUALITY CONTROL

At a meeting of the Society held April 10, 1945 nominations for new officers were made. The election of officers will be held at the June 12 meeting. Speakers at the April meeting were: Mr. Reuben Bruner of the Perfect Circle Company who spoke on "The Experiences and Problems Encountered in Grinding Piston Rings"; Mr. William Bulkley from Servel on "Time for Action from the Control Chart"; Dr.. Burr on "The Use of Sampling Inspection Tables". and Mr. Arthur Updike of Lukas-Harold on "Graphic Presentation"; and Mr. Arthur Bender on "A Study of Variations in the Manufacturing of Grids for Storage Batteries". The June 12 meeting will present speakers from Kingsbury, Carnegie Illinois, RCA, P.R. Mallory and Tube Turns.

COLUMBUS OHIO QUALITY CONTROL SOCIETY

The first meeting of the Columbus Group held March 29, 1945 indicated an enthusiastic response and approval of quality control by statistical methods. The meeting was devoted to reports from members covering the successes encountered after installing statistical methods during the manufacturing processes. Suggestions were also made to aid members in starting a control chart program.

DETROIT SOCIETY OF QUALITY CONTROL ENGINEERS

The April 25 meeting of the Society convened at 7:30 P. M. at the Engineering Section, Rackham Memorial. Two major papers composed the program: Quality Control in the Foundry, Irving E. R. Benson, Cadillac Motor, and Quality Control Technique, Control Charts, A. R. Jackson, Curtiss Wright, Columbus, Ohio.

The Society is compiling a year book of its membership. It is also in the midst of setting up an employment service. Both of these projects are expected to have considerable value immediately and in the postwar period.

The next meeting will be held June 5 with G. L. Smith, Director of Quality Control, Bell Aircraft, Buffalo, as principal speaker.

SOCIETY FOR STATISTICAL QUALITY CONTROL

A meeting held at Newark, New Jersey on March 25 was addressed by Mr. A. J. Winterhalter, Colonial Radio Corporation, and President of the Buffalo Society of Quality Control Engineers and Mr. E. B. Ferrell, Bell Telephone Laboratories, under the chairmanship of Mr. R. E. Wareham, General Electric Company. Mr. Winterhalter discussed "Installation of a Quality Control System". Mr. Ferrell's subject was "Control Chart Analysis of Performance During Life".

A meeting on April 25 was held as a joint meeting of the Society For Statistical Quality Control with the Society for Advancement of Management, Northern New Jersey Chapter. Mr. J. M. Juran, Assistant Adminstrator of the Foreign Economic Administration spoke on the subject "How to Present Quality Control to Management". The next meeting scheduled for May 25 will deal with the rubber industry.

KINGSBURY ORDNANCE PLANT

Ten graduates of the OPRD eight day intensive course and an additional 25 graduates of a part time fifteen week course taught by Professor Calkins of Notre Dame University provides Kingsbury with many well trained men for quality control work. The applications that have been made in the background area of chemical analysis, although not publically available, have been most fruitful. Control of mechanical operations has been somewhat difficult because of continuously changing requirements of the services. Nevertheless, the efficiency of operations on the shell loading lines has been improved.

TENNESSEE QUALITY CONTROL GROUP

The continuation meetings of the Group have been completed. Many applications of control procedure were reported at these meetings. Future meetings will be held as the members make sufficient progress to be ready to report.. Chester T. Rayme, American Lava, Chattanooga, has introduced control procedure in connection with products involving many unique problems. When this story is ready for presentation, it will provide material for a most instructive meeting.

Fulton Sylphon Valve, Knoxville, has made appreciable savings through the introduction of improved inspection, notably the replacement of 100% screening by sampling in a number of line operations and in assembly.

ILLINOIS QUALITY CONTROL GROUP

The second continuation meeting of the Illinois Group was held March 23 at the University of Illinois. The preparation of a plan for permanent organization was placed in the hands of a committee composed by Nick Kouzmonoff, Micro-Switch, F. T. Pettit, Caterpillar Tractor, and R. M. Johnson, American Machine and Metals. Papers were presented by Carl Noble, Electric Eye Equipment, T. W. Frank, American Flange and Mfg., O. K. Bower, University of Illinois, and Paul Peach of O.P.R.D. Twenty-two men who attended this meeting obtained valuable information on what can be done by even a brief application of quality control procedure..

Evidence of the value of these meetings is shown by their extention in the future to include Saturday morning sessions. The third meeting April 27-28 was devoted to papers and discussions of metallurgical problems, training programs, and the use of Simon's chart. The fourth meeting will be held May 25-26.

CURRENT PUBLICATIONS AND BIBLIOGRAPHY

A page of each issue of the Journal is devoted to brief reviews of articles on Statistical Quality Control appearing in current publications. Earlier issues of the Journal contain bibliographies of materials published in former years. The purpose is to provide readers with a permanent reference list. In compiling this historical list omissions are inevitable. Assistance from readers by supplying missing references will be appreciated.

BIBLIOGRAPHY

(Continued from March issue)

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McCARROLL, R.H., and McCLOUD, J. J., "Quality Control of Engineering Materials During Manufacturing and Processing," S.A.E. Journal (Transactions), August.

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MANUELE, JOSEPH, "New Way of Controlling the Quality of your Product," Ceramic Industry, November.

GHERING, L. G., "Refined Method of Control of Cordiness and Workability of Glass During Production; Statistical Control Charts of Daily Measurements of Density," American Ceramics Society Journal, December 1.

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1945

GODDESS, E., "Quality Control in Tube Manufacture," Electronics, January.

STURTEVANT, J. V., "Statistical Quality Control 1944," Metals and Alloys, January.

STEPHENS, C. G. and RUTHERFORD, J., "Statistical Methods in Quality Control; Glenn L. Martin Company," Factory Management, January.

CUTTER, G.O., "Simplified Approach to Quality Control," Iron Age, February 15.

BISBEE, R. F., "Quality Control of Enameling Steels; Suppliers of Steel Graded Quarterly; Westinghouse Electric and Manufacturing Company," Steel, February 26.

GREEN, A. W. F., "Consumer Control of Quality by Inspection," Metal Progress, February.

MORAN, RAYMOND F., "Determination of the Precision of Analytical Control Methods," Industrial and Engineering Chemistry, Analytical Edition, June 1943.

REVIEWS

THE WELDING JOURNAL

In the January issue is an article by Nathan C. Clark, Senior Research Engineer of Lockheed Aircraft Corporation entitled, "Quality Control in Aircraft Spotwelding".

The article explains that the practical solution to the problem of spot weld control involves three basic requirements, (1) standardization of the equipment and process, (2) the application of statistical control and (3) the monitoring of the spot welding machines or non-destructive testing of finished product.

FACTORY MANAGEMENT AND MAINTENANCE

The January issue contains a most interesting article by C. G. Stephens and J. Rutherford entitled, "Statistical Methods in Quality Control". This article features sampling inspection as related to magnetic inspection and includes a new idea as to the actual structural failure of bolts bearing magnetic indications - an interesting item is the method of proving sampling results.

ANALYSIS OF DOUBLE SAMPLING PLAN

(Continued from Page 10)

AOQ is a maximum may be found by differentiating Equation (6) with respect to p, equating to 0, and solving for p. The maximum value of average outgoing quality (AOQL) may then be found by substituting this value of p in Equation (6) together with the corresponding value of P_a. As this procedure is rather involved a satisfactory approximation may be found by an examination of the curve of average outgoing quality vs fraction defective in submitted product and taking the value of the highest ordinate. For the particular plan analyzed these values of AOQL are found to be very nearly .0130 for the first sample and very nearly .0152 for the combined samples.

The analysis of this sampling inspection plan has been carried out in considerable detail with the thought in mind that it may be helpful to others. Many statements have been made and much material has been repeated which may seem obvious to those who are familiar with the procedures involved. The preparation of these comments and explanations, however, was intended primarily for those who are interested in becoming more familiar with the principles involved and to serve as a ready reference for those who already have become accustomed to their use.

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J. Glen Strieby, Quality Control Engineer of Kimberly-Clark Corporation recently visited the Buffalo area.

The Society For Statistical Quality Control at Newark, N. J. is offering a one year subscription to Industrial Quality Control for the best paper of the year presented at their meetings.

INDUSTRIAL QUALITY CONTROL

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